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Markup cyclicality, competition and liquidity constraints: Evidence from a panel VAR analysis

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Abstract

The main scope of this study is to investigate the effects of competition and liquidity constraints on the cyclical behaviour of the markup ratio. In particular, 79 2-digit NACE Rev.2 sectors across the UK manufacturing and services industry over 2008–2017 are taken into account in order to observe markup cyclicality and whether pricing decisions are significantly influenced by the degree of competition and liquidity restrictions. A panel VAR framework is used to take into account the presence of cross-section dependence and heterogeneity amongst the regressors of the model. The empirical results provide the following significant insights: (a) the markup ratio across the UK sectors follows a countercyclical pattern, (b) concentrated sectors tend to charge countercyclical price–cost margins as they attempt to increase their market share in normal periods and (c) sectors with liquidity constrained firms charge countercyclical markups in order to substitute lack of funding with additional revenue. Complementary findings also suggest that more profitable firms charge procyclical markup ratios, thus validating predatory pricing strategies in more concentrated sectors.

KEYWORDS

concentration, liquidity constraints, manufacturing industry, markup ratio, services industry, UK

JEL CLASSIFICATION

D43; E31; L13; L60; L80

1 | INTRODUCTION

Firms across industries tend to form their pricing strategies according to expected consumer demand and various supply factors contributing in the production process. There is sufficient empirical evidence that two of the most important supply factors influencing pricing decisions are the degree of competition within sectors and the degree of firm accessibility to liquidity (Badinger, 2007; Bellone, Musso, Nesta, & Warzynski, 2016; Bernanke, Gertler, & Gilchrist, 1996; Braun & Larrain, 2005). Firms can use their market power to increase their revenue either through higher selling prices, when demand is inelastic, or through lower prices when demand is quite elastic. Therefore, price wars occur among the competitors.

Nevertheless, a firm's strategy is highly shaped by the value of assets, the efficiency of capital equipment and ultimately, by access to credit that will be used to fund the production process. For this reason, liquidity needs vary across sectors as more competitive firms may require additional funding. Any barriers restricting access to liquidity may force firms to reduce investment on labour and capital equipment, thus leading to reduced production (Braun & Raddatz, 2016; Raddatz, 2006).

Liquidity constraints may force firms to obtain additional funding through pricing decisions shaped by the nature of competition and business cycles. According to Chevalier and Scharfstein (1995, 1996), firms can exploit their market power during normal periods by charging lower prices. The duration of this strategy depends on the degree of available funding as firms with higher liquidity constraints will not be able to maintain low prices for long. Moreover, markups are much less likely to decline over recessions as firms wish to maximize consumer surplus exploitation from their existing consumers. If competition is quite intense, firms may engage in price wars even over a downturn as higher market shares may result in higher revenue in the short-run. This means that pricing strategies highly depend on the competitive structure of markets and the degree of available liquidity that can be invested in the production process.

This study takes into account the aforementioned process and investigates the role of competitive conditions and liquidity constraints on the cyclicality of markups. When uneven liquidity constraints arise among firms, it is expected that predatory pricing strategies will be adopted by less liquidity constrained firms in the short-run. This strategy occurs as the main intention is to weaken or even force competitors to exit the market (Rotemberg & Saloner, 1986). Therefore, the outcome of this process could suggest more coutnercyclical markup ratios across industries with such characteristics. Many studies in the literature investigate the effects of competition and liquidity constraints on pricing decisions across many countries (Bottasso & Sembenelli, 2001; Braun & Raddatz, 2016; Busse, 2002; Chevalier & Scharfstein, 1995, 1996; Hoberg & Phillips, 2010; Makaew & Maksimovic, 2013). They take into account the degree of firm heterogeneity within markets and report various outcomes on this relationship.[1]

For this reason, the present analysis considers a large number of UK manufacturing and services firms grouped into 79 2-digit NACE Rev.2 sectors over 2008–2017 in order to investigate the effects of competition and liquidity constraints on the cyclicality of markup. The UK economy is characterized by highly competitive characteristics across the OECD group as firms tend to increase their market share by charging a selling price close to the marginal cost of production (Afonso & Costa, 2013; Amountzias, 2018; Christopoulou & Vermeulen, 2012; Görg & Warzynski, 2003, 2006; Polemis & Fotis, 2016). This aspect makes it an interesting case study as intense competitive interactions may provide different results compared to other economies.

The methodology provided by De Loecker and Warzynski (2012) and Hall (1988) and Roeger (1995) is used in order to estimate the markup ratio charged by the constituent UK sectors.[2] Subsequently, a panel Vector Autoregression (VAR) framework will be used to take into account the issues of cross section dependence and heterogeneity as a pooled Ordinary Least Squares (OLS) estimation technique may result in incorrect inferences. The final estimates will reflect the behaviour of markups across the sectors and whether they are influenced by the explanatory variables capturing the effects of competition and liquidity. Therefore, the findings of this paper aim to complement the existing literature and provide an interpretation of how UK firms tend to set their selling prices under the pressure of restricted funding and competition. Moreover, as the UK markets are considered to be more competitive compared to other OECD markets, it is of great importance to investigate whether liquidity restrictions cause markup ratios to be more procyclical or countercyclical as the existing literature has not still reached a conclusive outcome (Braun & Raddatz, 2016).

This article is organized as follows: Section 2 provides the theoretical and empirical literature on competition, liquidity constraints and markups; Section 3 presents the methodological approach and data collection; Section 4 discusses the empirical findings; and Section 5 offers a conclusion.

2 | LITERATURE REVIEW

2.1 | Market competition and markups

Competing firms try to attract customers by satisfying their preferences through various strategies. One of the most important elements of such strategies are price setting decisions as consumers always prefer a lower price for the same product. For this reason, firms may compete in prices according to their available funding and resources and thus, they try to increase their market share given the elasticity of demand in the market. Stigler (1964) and Green and Porter (1984) argue that firms may adopt this particular rationale when overall conditions in the market improve and thus, consumers are willing to spend more for consumption. Under this assumption, firms will try to increase their market share by charging prices close to the marginal cost of production attempting to attract as many customers as possible.[3]

Rotemberg and Saloner (1986) also argue that colluding oligopolies behave more competitive during periods of high demand to increase their market share. Collusions tend to charge lower markups over normal periods in order to avoid any defection that could break down their agreement. Such behaviour has macroeconomic effects as an increase in demand for the products of oligopolies will lead to an increase in competition by efficiently boosting output. Price wars may occur in times of expansion due to the relationship between business cycles and slow price adjustment. Therefore, markups reflect a countercyclical behaviour as firms tend to reduce their prices when the market is larger, especially when available funding and resources allow such strategies to occur for some time.[4]

Moreover, competitive interactions depend on several market factors, such as the structure of the industry or the nature of the final product. As the manufacturing and services industries are the main contributors to national GDP across many economies, there are many empirical studies putting to test the aforementioned theoretical relationship between concentration and price setting decisions.[5] Ariga, Ohkusa, and Nishimura (1999) and Volpe, Okrent, and Kuhns (2017) argue that market concentration is a crucial determinant of markups as more concentrated firms take into account factors such as advertising and sales promotion efforts to increase their market share. When this is achieved, they tend to increase the selling price of products as consumers set their preferences for the products of those particular firms. Nicoletti and Scarpetta (2005, 2006) also support that less concentrated sectors tend to invest in technological advancement in order to boost their productivity and increase their market share. This process enhances the quality of their products and they become more attractive to customers.[6] McAdam et al. (2019) find the same outcome for the Euro Area markets by highlighting their propensity to invest in high technologies, thus boosting their operational growth rates. As they tend to invest in high technology projects, the dynamics of the price–cost margin over the years has remained quite stable reflecting the market power acquired through such investment decisions.

Moreover, Mishra (2008) reports the significance of a positive relationship between market concentration and pricing decisions; however, the core argument of this study is that external structural factors, such as government regulations, may break this relationship and force concentrated sectors to behave competitively. This outcome may occur when barriers to entry are relatively low so new entrants can enjoy an equivalent competitive advantage with the incumbent firms and thus, establish their presence in the market. Cerullo et al. (2018) also argue that the structural nature of markets highly influence the competitive interactions among firms. In particular, they support that hospitals with for-profit status in highly concentrated markets do not necessarily charge higher markups compared to public/private not-for-profit status as their findings vary according to the degree of concentration across different markets. Therefore, structural and institutional elements significantly shape the pricing decisions of firms.

An additional factor influencing pricing decisions is the structural characteristics and domestic exposure to international markets through imports and exports. Liu and Ma (2015) support that market structure is an important determinant of market power exercise along with international trade interactions. As the price of imported inputs highly influence the cost of production, less competitive importers tend to increase the markup ratio when input tariffs are reduced. Such outcome reflects a profit-seeking behaviour in order for importing firms to boost their share and their power overall in the market.

On the other hand, Görg and Warzynski (2003) and Amountzias (2018) find that export-oriented firms in the United Kingdom tend to charge a higher markup compared to their domestic competitors. They can charge different prices across different markets by taking into account their power and their ability to sustain a high price–cost margin over a particular period. This means that exporting firms may charge a higher markup in international markets, while keeping their prices low in domestic markets, thus increasing their market share through funding transition. De Loecker (2007), De Loecker and Warzynski (2012) and Polemis and Fotis (2016) also provide similar evidence arguing that exporting firms tend to enjoy a higher market share in domestic markets as they boost their power using revenue earned from international activities.

However, Görg and Warzynski (2006) and Amountzias (2018) provide no insights about the cyclical behaviour of markups and thus, there is not sufficient evidence about the dynamics of this process. Moreover, the literature of pricing decisions is far from reaching a conclusive outcome about markup cyclicality and whether it follows a similar pattern according to the measures of the aggregate economy. Afrouzi (2016) provides evidence of procyclical markup ratios when firms have incentives for implicit collusion rather than competitive interactions. This means that the size and the bargaining power in the market influence the cyclicality of markups: larger firms tend to exploit market power when the economy is growing, but they engage in price wars when recession occurs. This outcome is validated by Autor, Dorn, Katz, Patterson, and Van Reenen (2020) and Hong (2018) arguing that large firms are able to exploit their market power due to the continuous rise in the corporate share of profits and the simultaneous decline in the labour share of revenue over the last 30 years.

Molnár and Bottini (2010) highlight the significance of market characteristics across different economies and how particular institutional factors may influence the pricing decisions of firms. By estimating the markup ratios across several EU manufacturing and services industries, they found that the UK and Scandinavian (excluding Sweden) sectors tend to be more competitive compared to Central European countries (Polemis, 2014). Moreover, Christopoulou and Vermeulen (2012) argue that the manufacturing industry on average is more competitive compared to the services industry. This outcomes lies on several market characteristics that each sector encounters as factors, such as market regulations, demand elasticity, export-orientation and available funding, tend to affect markup cyclicality and ultimately, the pricing strategies of firms shaping the structure of the market. Therefore, markup behaviour depends on market concentration and the power of the incumbent firms to set high markup ratios or engage in price wars to secure market share and force their competitors to exit the market.

2.2 | Liquidity constraints and markup cyclicality

Many empirical studies investigate the behaviour of markup cyclicality according to liquidity constraints and how financial barriers may result in market share losses. As firms struggle to secure additional funding to invest in the production process, their pricing decisions will have to reflect the available level of liquidity. Chevalier and Scharfstein (1995, 1996) provided significant evidence that liquidity constraints tend to make markups more countercyclical because firms adopt a pricing behaviour proposed by Rotemberg and Saloner (1986). This means that firms reduce their markups in normal times to attract more customers and increase their market share. However, markup ratios are increased over downturns to extract consumer surplus and thus, increase their revenue and boost their liquidity reserves. This behaviour occurs because firms heavily relying on external financing are more likely to suspend their investment in market share building in response to negative demand shocks that affect pricing decisions and the outcome of competitive interactions (Campello, 2003).

Bottasso and Sembenelli (2001) and Busse (2002) also argued that financial constraints and industry debt is a crucial determinant influencing markup behaviour. As firms become more indebted and dependent on external financing, they are more likely to cut prices and engage in price wars in order to increase their market share and consequently, their revenue. This strategy allows firms to build their market share in the short-run and exploit consumer surplus through predatory pricing decisions in the long-run if they establish their presence in the market. Therefore, the degree of financial constraints and competition in the market heavily influence markup cyclicality and the pricing strategies of firms overall.

Braun and Raddatz (2016) provided significant empirical evidence showing that markups tend to increase with business cycles in more competitive markets where firms are liquidity constrained in the short-run. Competition and financing activities appear to have a strong relationship with markup cyclicality as more competitive industries are more procyclical compared to more concentrated industries. Consequently, less financially constrained firms with a relatively low market share tend to make markups procyclical when they operate in industries where many firms face significant liquidity constraints. This suggestion is in line with predatory pricing decisions as firms with lower liquidity needs may charge lower prices over downturns to weaken their competitors and ultimately, force them to exit the market.

Campello, Graham, and Harvey (2010) and Liu and Mello (2017) also argued according to this line of reasoning regarding the effects of financial constraints. Restricted access to liquidity will force firms to cut investment in the production process, thus reducing capital and labour overall. Moreover, if they face short-run liabilities, they will have to improve their liquidity ratio by selling assets to acquire cash that can be used to finance those liabilities. Such constraints may force firms to charge a relatively high markup ratio when they expect that additional revenue will be used to substitute liquidity needs unable to be financed through external lending. For this reason, firms operating in more than one markets can charge different prices according to the degree of demand elasticity (Bellone, Musso, Nesta, & Schiavo, 2010). Markets with more inelastic demand provide the opportunity for charging higher selling prices resulting in higher revenue. Therefore, liquidity can be transferred to highly competitive markets and provide an advantage over competing firms, especially when demand is highly elastic.

Overall, markup cyclicality significantly depends on financial constraints and competitive interactions across industries. Liquidity-constrained firms operating in competitive environments tend to be procyclical as they may have large markup declines over downturns. Predatory pricing strategies may be adopted by more liquidity-unconstrained firms to force their competitors out of the market and ultimately, acquire additional power through higher market share.

3 | METHODOLOGY AND DATA COLLECTION

3.1 | Markup ratio estimation

The main indicator of pricing decisions utilized in this study is the markup ratio charged by firms reflecting the difference between value added and the costs of production. The methodological formulation of the price–cost margin is attempted by employing the techniques introduced by Hall (1988), Roeger (1995) and De Loecker and Warzynski (2012). In particular, De Loecker and Warzynski (2012) provided significant evidence that the Hall–Roeger approach usually results in underestimated markups as it takes into account the growth rates of value added and production costs, thus neglecting the relationship between variables at levels. Moreover, they argue that the latter formulation provides a methodological advantage compared to traditional approaches, such as the Lerner index, because it takes into account output elasticity with respect to production costs. Under this approach, the markup ratio is more accurate as production fluctuations are included in the final estimated value.

For this reason, the current study employs and compares both formulations in order to check the robustness of the final estimates and whether any major deviations occur in the estimated markup ratios. In particular, the price–cost margin under both approaches is obtained by leveraging cost minimisation of an input factor in the production process. It is assumed that N heterogeneous firms operate within an industry having access to a common production technology. The production function of each firm i, where $i = 1,2,...,N$ is captured by

$$Q(A_{it},V_{it},K_{it}) = A_{it}Q(V_{it},K_{it}) \tag{1}$$

where $Q(.)$is the production function, A_{it} is the Hicks-neutral productivity factor which is heterogeneous across firms, $V = (V_1, ..., V_j)$ is the set of variable inputs used in the production process[7] and K is the capital stock. The Lagrangian objective function for the variable inputs is given by

$$L(V_{it},K_{it},\lambda_{it}) = {P_{it}}^V V_{it} + r_{it}K_{it} - \lambda_{it}[Q(A_{it},V_{it},K_{it}) - Q_{it}] \tag{2}$$

where ${P_{it}}^V$ is the price of variable input V, r_{it} is the user cost of capital,[8] λ is the Lagrangian multiplier and Q_{it} is a scalar.

At this point, the model formulation of Hall (1988) and Roeger (1995) is captured by

$$\Delta Y_t = \left(\frac{\Delta y_t}{y_t} + \frac{\Delta p_t}{p_t}\right) - \left(\frac{\Delta k_t}{k_t} + \frac{\Delta u_t}{u_t}\right) \tag{3a}$$

$$\begin{aligned}\Delta X_t = a_{mt}&\left[\left(\frac{\Delta m_t}{m_t} + \frac{\Delta pm_t}{pm_t}\right) - \left(\frac{\Delta k_t}{k_t} + \frac{\Delta u_t}{u_t}\right)\right]\\ &+ a_{lt}\left[\left(\frac{\Delta l_t}{l_t} + \frac{\Delta w_t}{w_t}\right) - \left(\frac{\Delta k_t}{k_t} + \frac{\Delta u_t}{u_t}\right)\right]\end{aligned} \tag{3b}$$

where $a_{m_t} = pm_t m_t / p_t y_t$ is the share of intermediate inputs in output, pm_t is the price of intermediate inputs, $a_{l_t} = w_t l_t / p_t y_t$ refers to the share of labour expenses in output, w_t is the wage rate, p_t is the price level of output and u_t is the user cost of capital. ΔY_t corresponds to the growth rate of output per unit of capital, and ΔX_t represents the growth rate of intermediate inputs and labour expenses per unit of capital. Therefore, the difference of growth rates between (3a) and (3b) results in the markup ratio charged by firms.

On the other hand, De Loecker and Warzynski (2012) depart from this approach and provide the first-order condition of Equation (2) with respect to the variable input V

$$\frac{\partial L_{it}}{\partial V_{it}} = {P_{it}}^V - \lambda_{it}\left(\frac{\partial Q(A_{it},V_{it},K_{it})}{\partial V_{it}}\right) \tag{4}$$

If this expression is multiplied by V_{it}/Q_{it} and rearranged, output elasticity with respect to variable input V is obtained

$${\beta_{it}}^V = \frac{\partial Q(A_{it},V_{it},K_{it})}{\partial V_{it}}\frac{V_{it}}{Q_{it}} = \frac{1}{\lambda_{it}}\frac{{P_{it}}^V V_{it}}{Q_{it}} \tag{5}$$

This expression captures the dynamics of the production process as λ reflects the marginal cost of production according to the value of inputs. Moreover, given that P is the price of the final product, then P/λ can be interpreted as the price markup over the marginal cost of production. Under perfect competition, it is expected that the price–cost margin is equal to unity, thus $P = \lambda$. Under any form of imperfect competition, the price level should exceed the marginal cost of production; the higher the difference, the higher the degree of market power as firms are expected to charge a price closer to the monopolistic price level. Therefore, Equation (5) can be rewritten as

$$\mu_{it} = \beta_{it}{}^{V} \frac{P_{it} Q_{it}}{P_{it}{}^{V} V_{it}} \tag{6}$$

Equation (6) includes two important elements that shape the value of the price–cost margin: the ratio of revenue to the value of input V and the elasticity of output with respect to the variable input. The inclusion of the latter element provides a significant advantage to this formulation as the observation of the market demand function is not necessary. According to Bils, Klenow, and Malin (2018), intermediate inputs play an important role in the formulation of the markup ratio due to their flexibility. If labour compensation is treated as the only variable input, the price–cost margin may result in overestimated values because a crucial determinant in the production process is neglected. To this end, the variable inputs taken into account in Equation (6) reflect the value of intermediate inputs in the production process and labour compensation. Moreover, Equation (6) must satisfy the assumption of a production function according to (1) and the presence of perfect competition in the market of inputs.[9]

The estimation process of Equation (6) necessitates the observation of total sales $P_{it}Q_{it}$ and the total variable cost of production $\sum_j P_{it}{}^{V\,j} V_{it}{}^{j}$. Therefore, an industry-specific Cobb–Douglas production function is employed by adding logarithms to Equation (1)

$$q_{it} = a_{it} + \beta_v v_{it} + \beta_k k_{it} + u_{it} \tag{7a}$$

At this point, the suggestions of De Loecker, Eeckhout and Unger (2020) are implemented in this expression to control for simultaneity and selection bias in order to obtain an unbiased output elasticity value with respect to variable inputs. This means that the input demand equation included in the Lagrangian expression (2) must be taken into account. Finally, if the unobserved productivity term A depends on the input factors used in the production process (Olley & Pakes, 1996), Equation (7a) is transformed into

$$q_{it} = a_{it} + \beta_v v_{it} + \beta_k k_{it} + w_{it} + u_{it} = \psi_t(v_{it}, k_{it}) + u_{it} \tag{7b}$$

where $w_{it} = w(v_{it}, k_{it})$ is the unobserved productivity term. If that term is assumed to follow an AR(1) process, the industry specific output elasticity is obtained by the moment condition

$$E[w_{it}(\beta_v) v_{it-1}] = 0 \tag{8}$$

where the estimated value of ψ is used to obtain the value of output elasticity with respect to variable inputs. This formulation assumes that variable inputs at time t respond to productivity shocks. Moreover, the AR(1) process reflects a degree of correlation between the current and lagged values suggesting the persistence of those shocks over time. Consequently, the firm-level markup ratio is obtained by

$$\mu_{it} = \beta_v \frac{P_{it} Q_{it}}{\sum_j P_{it}{}^{V\,j} V_{it}{}^{j}} \tag{9}$$

3.2 | Model formulation and data collection

As the main objective of this study is to investigate the effects of competition and financial constraints on markup cyclicality, the markup ratio captured by Equation (9) will be taken into account (De Loecker, Eeckhout and Unger, 2020). The main aim of this model is to investigate whether liquidity constraints and market concentration have a significant effect on the pricing decisions of firms. Braun and Raddatz (2016) introduce the importance of liquidity provisions to firms operating in concentrated industries as firms with higher liquidity reserves may be able to pursue predatory pricing strategies in the short-run to increase their share over time. In this case, market power acquisition will be reflected on the markup ratio as limited competition will result in a small number of firms operating in the industry, thus increasing consumer surplus exploitation in the long run. For this reason, it is expected that the interaction between market concentration and liquidity constraints has a significant effect on the price–cost margin of the UK firms.

Moreover, a number of control variables will be included in the model to test the significance of the aforementioned effects on the cyclical behaviour of pricing decisions. The studies of Konings et al. (2005), Raddatz (2006) and Braun and Raddatz (2016) are considered for the formulation of accurate and sufficient indicators of competition and liquidity constraints. To this end, the functional equation of the model is the following:

$$\begin{aligned} \text{markup}_{\text{it}} &= b_0 + b_1 \text{concentration}_{\text{it}} + b_2 \text{liquidity constraints}_{\text{it}} + \\ &+ b_3 \text{profitability}_{\text{it}} + b_4 \textit{investment}_{it} + b_5 \text{liquidity needs}_{\text{it}} + u_{\text{it}} \end{aligned} \tag{10}$$

The main rationale captured by Equation (10) reflects the determinants of pricing decisions that firms must face by taking into account the competitive behaviour of other firms and their available liquidity to invest in the production process. Moreover, as investment decisions and pricing strategies are set with profitability as the ulterior motive, it is expected that firms will have to utilize their available liquidity efficiently in order to cope up with market competition. Firms with lower liquidity reserves will need additional funding to attract more customers through lower markup ratios and thus, to reduce the competitive advantage enjoyed by their competitors. To this end, the effect of market concentration and liquidity constraints on the price–cost margin is investigated by Equation (10), when investment decisions, profitability and liquidity needs are considered as control variables (Braun & Raddatz, 2016). According to theoretical intuition reflected by the model, the set of regressions that will be estimated is provided by

$$\mu_{it} = \mu(cr_{it}, lc_{it}, inv_{it}, pr_{it}, ccc_{it}) \tag{10a}$$

$$\mu_{it} = \mu(cr_{it}, lc_{it}, inv_{it}, pr_{it}, dr_{it}) \tag{10b}$$

$$\mu_{it} = \mu(cr_{it}, lc_{it}, inv_{it}, pr_{it}, lr_{it}) \tag{10c}$$

$$\mu_{it} = \mu(g_{it}, g*cr_{it}, g*lc_{it}, g*inv_{it}, g*pr_{it}, g*ccc_{it}) \tag{11a}$$

$$\mu_{it} = \mu(g_{it}, g*cr_{it}, g*lc_{it}, g*inv_{it}, g*pr_{it}, g*dr_{it}) \tag{11b}$$

$$\mu_{it} = \mu(g_{it}, g*cr_{it}, g*lc_{it}, g*inv_{it}, g*pr_{it}, g*lr_{it}) \tag{11c}$$

where μ is the markup ratio calculated from Equation (9) for every industry i, g is the growth rate of GDP, cr is the concentration ratio of each individual firm within a specified sector and lc is an indicator of liquidity constraints that firm i faces when it wishes to acquire additional credit. The control variables correspond to inv which is the ratio of investment to operating revenue, pr is a profitability indicator and ccc is a proxy of cash conversion cycle reflecting the time needed for firm i to acquire cash from trading and financial activities. The short-term debt-to-operating revenue ratio dr and the labour compensation-to-operating revenue ratio lr are also considered as indicators of liquidity needs to check the robustness of this factor on the behaviour of markups.

The dataset consists of 4.040 UK manufacturing and services firms aggregated into 79 2-digit NACE Rev.2 sectors over 2008–2017 and it was obtained by the Bureau van Dijk FAME, the AMECO and the World Bank databases.[10] The current dataset aims to extend the studies of Afonso and Costa (2013) and Braun and Raddatz (2016) and provide significant evidence of the relationship between markup cyclicality and liquidity constraints across the UK economy.[11,12]

The markup ratio is formulated by employing Equations (3a)-(9) where intermediate inputs and labour costs are the variable inputs in the production process. Output is expressed as operating revenue or turnover, the value of intermediate inputs is reflected by the cost of sales, labour costs are captured by labour compensation and finally, the user cost of capital is formulated by $u_t = [(i - \pi_e) + \delta]F_t$, where $(i - \pi_e)$ is the real interest rate, F_t is the deflator of fixed asset investment for total economy and δ is the depreciation rate which is equal to 5% across all industries[13] (Martins et al., 1996). The formulation of the markup ratio in Equation (9) is provided according to the suggestions of De Loecker, Eeckhout and Unger (2020) to control for simultaneity and selection bias that result in an unbiased output elasticity value with respect to variable inputs. Consequently, the cyclical behaviour of the markup ratio is observed by multiplying the growth rate of GDP with the explanatory variables of the model over 2008–2017.

The concentration ratio is formulated as the operating revenue of each constituent firm i over the value of operating revenue within a specified sector. This indicator reflects the degree of concentration in the market and can be related with market power expressed by a positive price–cost margin. Konings et al. (2005) and Feenstra and Weinstein (2010) also support this argument as more concentrated industries tend to charge a higher markup ratio. Market concentration indicators have been considered by several papers (Amountzias, 2018; Ariga et al., 1999; Mishra, 2008) and to this end, they are accurate measures of investigating market power exploitation through higher price–cost margins charged by firms.[14] The main rationale of including a concentration index in the estimation process is to observe how liquidity constrained firms operating in less competitive environments tend to set their markups (Braun & Raddatz, 2016). The concentration ratio is used in the model because it is a reliable proxy considering the operating revenue of every firm in the market, thus capturing forms of heterogeneity expressed by firm-level characteristics (Newbery, Green, Neuhoff, & Twomey, 2004).

The variable of liquidity constraints is formulated as the interaction between liquidity needs and a proxy of financial development (Braun & Raddatz, 2016). Liquidity needs is expressed as the ratio of inventories over operating surplus for each firm i (Raddatz, 2006). The financial development proxy corresponds to the firm-level liquidity ratio expressed as current liabilities over current assets. This is an accurate indicator of credit availability because it reflects the ability of firms to keep up with their short-run liabilities.[15]

However, the effect of liquidity needs on markup cyclicality must be tested even further as liquidity constraints is a combination of liquidity needs and financial development. For this reason, an additional proxy of liquidity needs is used as introduced by Raddatz (2006) reflecting the cash conversion cycle of firms. This indicator measures the time needed between the moment a firm pays for its intermediate inputs and the moment it is paid for the sale of the final product (Richards & Laughlin, 1980). Consequently, it captures the funding availability of a firm reflecting how it is influenced by increasing gaps between giving and receiving cash throughout the course of their operations.[16] The cash conversion cycle indicator is formulated as follows:

$$CCC = \frac{\text{inventory} * 365}{\text{cost of sales}} + \frac{\text{account receivables} * 365}{\text{operating revenue}} - \frac{\text{account payables} * 365}{\text{cost of sales}} \tag{12}$$

Two additional indicators are used in order to increase the robustness of the relationship between liquidity needs and markup cyclicality. The first indicator is the ratio of short-term debt to operating revenue and the second one is the labour compensation over operating revenue ratio. As the dataset consists of firm-level observations, those ratios are more accurate and reliable than aggregate variables because they capture the liquidity decisions of individual firms. Moreover, the aforementioned proxies are less volatile compared to the inventory to sales ratio as the inventory of durable goods producing firms may be higher and thus, it may result in overestimated values.

Finally, as investment decisions and profitability depend on available liquidity, the capital structure and the inventory of firms, it is important to investigate how they tend to affect markup cyclicality and how price–cost margins change over periods of growth and recession. For this reason, the ratio of investment to operating revenue and operating surplus before interest and taxation are added in Equations (10a)-(11c). It is expected that more profitable firms tend to face lower liquidity constraints, thus allowing them to increase investment and improve the production process. Consequently, such actions will influence their liquidity needs and ultimately, the behaviour of markup cyclicality.

3.3 | Panel VAR framework

As the dataset consists of 79 2-digit NACE Rev.2 sectors over 2008–2017, it is expected that a form of cross section dependence will emerge in the sample. The presence of this issue is tested by employing the LM and scaled tests developed by Pesaran (2004). If cross section dependence is significant, a pooled least squares estimator will result in inefficient estimates and thus, alternative estimation techniques must be considered. The tests utilize the average value of all pair-wise correlation coefficients of the OLS residuals obtained by the ADF regression of each variable in the model. The null hypothesis assumes the absence of contemporaneous correlation, thus rendering a simple pooled least squares estimator feasible for the model. The alternative hypothesis reflects the presence of such correlation under which the random or fixed effects model must be used (Baltagi, 2008).

Subsequently, the investigation of first-order integration must be carried out to identify whether any of the panel series is not stationary. In this case, non-stationarity results in incorrect inferences and thus, a panel VAR framework must be used. The unit root tests applied on the panel series of Equation (10) are Pesaran's (2007) cross section ADF tests (CADF), where the initial ADF regression is augmented by the cross section average values of lagged levels and first differences. This transformation considers the presence of cross section dependence across the panel set and thus, it provides more robust estimates compared to the simple ADF regression. If at least one of the series is found to be first-order integrated, the presence of cointegration must be tested in order to explore the presence of a long-run relationship in the model.

Consequently, Westerlund's (2008) cointegration test is applied on Equation (10) by considering the presence of cross section dependence in the model. The group and the panel Durbin–Hausman test statistics are formulated according to the presence of contemporaneous correlation and non-stationarity. The null hypothesis of both statistics reflects the presence of no cointegration and thus, the absence of a long-run relationship. The presence of cross section dependence is embodied by a factor model in which the residual terms are obtained by common unobservable factors across the constituent industries (Auteri & Costantini, 2010). Pedroni's (2004) statistics are also used to check the robustness of the results provided by the group and the panel Durbin–Hausman test statistics.[17]

When cointegration emerges in the model, a panel Vector Error Correction model is formulated in order to reflect the long-run relationship amongst the panel series. Moreover, when the dataset suffers from contemporaneous correlation, the most suitable estimation technique is the common correlated effects (CCE) developed by Pesaran (2006). The formulation process is similar to the one of CADF unit root test, where the main regression is augmented by the cross-section average values of the sectors over the 10 years of the sample. This approach allows individual specific error terms to be heteroskedastic and serially correlated.[18] However, it does not directly consider the presence of correlation between the explanatory variables and the error term. For this reason, the generalized method of moments (GMM) provided by Hansen (1982) and Arellano and Bover (1995) is also used to check the robustness of the final estimates and whether potential endogeneity may affect the significance of the results.

The final test utilized in the empirical process of Equation (10) is the non-Granger causality test developed by Dumitrescu and Hurlin (2012). As cointegration reflects long-run causality and transition to equilibrium, short-run causality results must also be provided in order to observe the short-run behaviour of the constituent variables. The test considers stationary series using the Z-bar statistic for the fixed coefficients of the explanatory variables under a panel VAR framework. The null hypothesis indicates the absence of causality in any cross-section of the panel set obtained by the Wald statistic which is run for every cross section, thus obtaining the average value of those statistics.[19] The advantage of this test compared to the traditional Granger causality test (Granger, 1969) is the assumption that coefficients are heterogeneous across the cross-sections.

Consequently, by employing the aforementioned methodological process, the long-run and short-run effects of competition and liquidity constraints will be tested on the cyclical behaviour of the price–cost margin.

4 | RESULTS AND DISCUSSION

The empirical process of the study is developed in two steps: the first step calculates the markup ratio for the constituent 79 2-digit UK sectors over 2008–2017 by employing Equation (9). The second step uses those estimates and embodies them in Equation (10) which is tested for the presence of cross section dependence and first-order integration. If the results of the diagnostic tests are significant, a panel VAR framework is formulated to tackle these problems and provide robust estimates. The main rationale of this process is to initially investigate the behaviour of the price–cost margin across the UK economy and ultimately, whether competitive interactions and liquidity constraints significantly shape pricing decisions and their cyclical behaviour.

Kufel (2016) supports that certain characteristics of various sectors influence the behaviour of markup cyclicality. This assumption however, holds for the EU manufacturing sectors over the last years but not for the aggregate EU food sector which is dominated by countercyclical markup ratios. In particular, many empirical studies provide significant evidence of such pricing behaviour as firms tend to engage in price wars over expansions in order to increase their market share. Bils et al. (2018) and Corhay, Kung, and Schmid (2017) support that markup ratios tend to be countercyclical as sticky prices and endogenous pricing decisions influence the risk of financial assets and thus, the long-run operation of firms in the industry. Hong (2017, 2018) also mentions that this rationale is dominant especially amongst small and medium sized firms as they place lower weight on future returns, thus leading them to charge higher markups over downturns.

Nevertheless, the cyclical behaviour of markups depends on various shocks that may influence consumer preferences or production decisions (Kim & Moon, 2017; Opp, Parlour, & Walden, 2014). In this case, pricing decisions will be adjusted to such shocks and ultimately, the interactions between firms and consumers will change in order to reflect the new conditions in the market. For this reason, the Hall–Roeger approach (Hall, 1988; Roeger, 1995) and the markup formulation of De Loecker and Warzynski (2012) will be used for the estimation of the price–cost margin across the constituent UK manufacturing and services sectors.

Tables 1 and 2 and Figure 1 reflect the markup ratios of the 79 2-digit UK sectors over 2008–2017. The results verify the empirical findings of Görg and Warzynski (2003, 2006) and Amountzias (2018) supporting the competitive nature of the UK sectors. The highest value is obtained by the manufacturing industry; however, two of the services sectors appear to exhibit the highest price–cost margin across the sample.[20] The pricing decisions adopted by the UK manufacturing and services industry reflect a price–cost margin equal to 19% which is quite competitive. Moreover, the theoretical suggestions of De Loecker and Warzynski (2012) about the Hall–Roeger approach (Hall, 1988; Roeger, 1995) are validated as on average, the estimates of the latter approach are underestimated compared to the values of the former.[21]

Moreover, Table 2 shows the summary statistics of the operating and liquidity-based indicators included in the model. Figures 2 and 3 reflect the dynamics of the constituent variables in the model suggesting that both industries have significantly grown over the years. As revenue tends to increase, the services industry overall faces an increasing trend in operating profit compared to the manufacturing industry which is growing at a slower rate following the period over 2012–2014. This outcome may be reflected by the higher investment-to-revenue ratio as services firms are more investment-oriented compared to manufacturing firms. Therefore, the former group of firms will require more liquidity to carry out their operating decisions.

Finally, the services industry appears to be less concentrated than the manufacturing industry, which is consistent with the markup ratios and the values presented in Tables 1 and 2. This means that a few manufacturing sectors seem to exercise their market power on the price–cost margin given that they serve a larger market share.

TABLE 1 Estimated markup ratios across the UK sectors

UK sectors	Markup ratio (De Loecker & Warzynski, 2012)	Markup ratio (Hall, 1988; Roeger, 1995)
Manufacturing and services industries	1.192	1.093
Manufacturing industry	1.261	1.154
Services industry	1.163	1.067
10 – Manufacture of food products	1.087	1.091
11 – Manufacture of beverages	1.647	1.793
12 – Manufacture of tobacco products	1.304	1.337
13 – Manufacture of textiles	1.727	1.815
14 – Manufacture of wearing apparel	1.936	1.981
15 – Manufacture of leather and related products	1.319	1.124
16 – Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	1.134	1.116
17 – Manufacture of paper and paper products	1.588	1.813
18 – Printing and reproduction of recorded media	1.051	1.059
19 – Manufacture of coke and refined petroleum products	1.009	1.059
20 – Manufacture of chemicals and chemical products	1.323	1.317
21 – Manufacture of basic pharmaceutical products and pharmaceutical preparations	2.069	1.901
22 – Manufacture of rubber and plastic products	1.206	1.126
	1.079	1.177

TABLE 1 (Continued)

UK sectors	Markup ratio (De Loecker & Warzynski, 2012)	Markup ratio (Hall, 1988; Roeger, 1995)
23 – Manufacture of other non-metallic mineral products		
24 – Manufacture of basic metals	1.069	1.029
25 – Manufacture of fabricated metal products, except machinery and equipment	1.045	1.066
26 – Manufacture of computer, electronic and optical products	1.996	2.041
27 – Manufacture of electrical equipment	1.035	1.046
28 – Manufacture of machinery and equipment n.e.c.	1.180	1.070
29 – Manufacture of motor vehicles, trailers and semi-trailers	1.238	1.019
30 – Manufacture of other transport equipment	1.043	1.045
31 – Manufacture of furniture	1.161	1.183
32 – Other manufacturing	1.313	1.312
33 – Repair and installation of machinery and equipment	1.290	1.240
35 – Electricity, gas, steam and air conditioning supply	1.124	1.100
36 – Water collection, treatment and supply	1.324	1.298
37 – Sewerage	1.052	0.819
38 – Waste collection, treatment and disposal activities; materials recovery	1.067	1.048
39 – Remediation activities and other waste management services.	1.032	0.921
	1.373	1.048

TABLE 1 (Continued)

UK sectors	Markup ratio (De Loecker & Warzynski, 2012)	Markup ratio (Hall, 1988; Roeger, 1995)
41 – Construction of buildings		
42 – Civil engineering	1.022	0.960
43 – Specialized construction activities	1.076	1.077
45 – Wholesale and retail trade and repair of motor vehicles and motorcycles	1.049	1.050
46 – Wholesale trade, except of motor vehicles and motorcycles	1.111	1.218
47 – Retail trade, except of motor vehicles and motorcycles	1.163	1.227
49 – Land transport and transport via pipelines	1.039	1.029
50 – Water transport	1.166	1.121
51 – Air transport	1.013	1.012
52 – Warehousing and support activities for transportation	1.014	1.052
53 – Postal and courier activities	1.555	1.894
55 – Accommodation	1.953	1.401
56 – Food and beverage service activities	1.050	1.100
58 – Publishing activities	1.192	1.185
59 – Motion picture, video and television programme production, sound recording and music publishing activities	1.178	1.239
60 – Programming and broadcasting activities	2.947	2.872
61 – Telecommunications	1.049	1.270

(Continues)

TABLE 1 (Continued)

UK sectors	Markup ratio (De Loecker & Warzynski, 2012)	Markup ratio (Hall, 1988; Roeger, 1995)
62 – Computer programming, consultancy and related activities	1.102	1.092
63 – Information service activities	1.009	1.168
64 – financial service activities, except insurance and pension funding	1.047	1.021
65 – Insurance, reinsurance and pension funding, except compulsory social security	1.126	0.972
66 – Activities auxiliary to financial services and insurance activities	1.007	1.005
68 – Real estate activities	1.162	1.178
69 - Legal and accounting activities	1.143	1.231
70 – Activities of head offices; management consultancy activities	1.085	1.193
71 – Architectural and engineering activities; technical testing and analysis	1.034	1.014
72 – Scientific research and development	1.968	2.090
73 – Advertising and market research	1.224	1.225
74 – Other professional, scientific and technical activities	1.083	1.122
75 – Veterinary activities	1.078	1.064
77 – Rental and leasing activities	1.223	1.229
78 – Employment activities	1.079	1.028

(Continues)

TABLE 1 (Continued)

UK sectors	Markup ratio (De Loecker & Warzynski, 2012)	Markup ratio (Hall, 1988; Roeger, 1995)
79 – Travel agency, tour operator and other reservation service and related activities	1.010	1.121
80 – Security and investigation activities	1.077	0.980
81 – Services to buildings and landscape activities	1.042	0.980
82 – Office administrative, office support and other business support activities	1.009	0.997
84 – Public administration and defence; compulsory social security	1.211	1.027
85 – Education	1.204	1.274
86 – Human health activities	1.008	0.896
87 – Residential care activities	1.061	1.000
88 – Social work activities without accommodation	1.070	0.988
90 – Creative, arts and entertainment activities	1.134	1.237
91 – Libraries, archives, museums and other cultural activities	2.485	1.994
92 – Gambling and betting activities	1.096	1.147
93 – Sports activities and amusement and recreation activities	1.432	1.536
94 – Activities of membership organisations	1.112	1.050
95 – Repair of computers and personal and household goods	1.037	0.993
96 – Other personal service activities	1.085	1.059
97 – Activities of households as employers of domestic personnel	1.071	0.998
RP – Residents property management	1.177	1.108

Note: The estimated values were obtained by Equations (3a), (3b) and (9).

TABLE 2 Summary statistics for the UK industries

	Manufacturing and services industries	Manufacturing industry	Services industry
Turnover (millions)	1,535.3	319.5	903.2
Cost of intermediate inputs (millions)	1,090.8	193.7	897.1
Labour compensation (millions)	204.2	41.6	162.5
Employees (millions)	6.94	1.01	5.94
Investment-to-operating revenue ratio	0.27	0.15	0.31
Profitability (millions)	119.4	29.9	89.4
Liquidity needs ratio	0.57	0.55	0.57
Concentration ratio	0.37	0.41	0.36
Cash conversion cycle index	0.44	0.46	0.44

To this end, it can be concluded that the UK services industry tends to be more competitive than the manufacturing industry by focusing on investment and liquidity acquisition in order to attract more customers and improve their production overall. Consequently, according to such evidence, the following step of the estimation process would be to check the cyclical behaviour of the estimated markup ratios and conclude whether

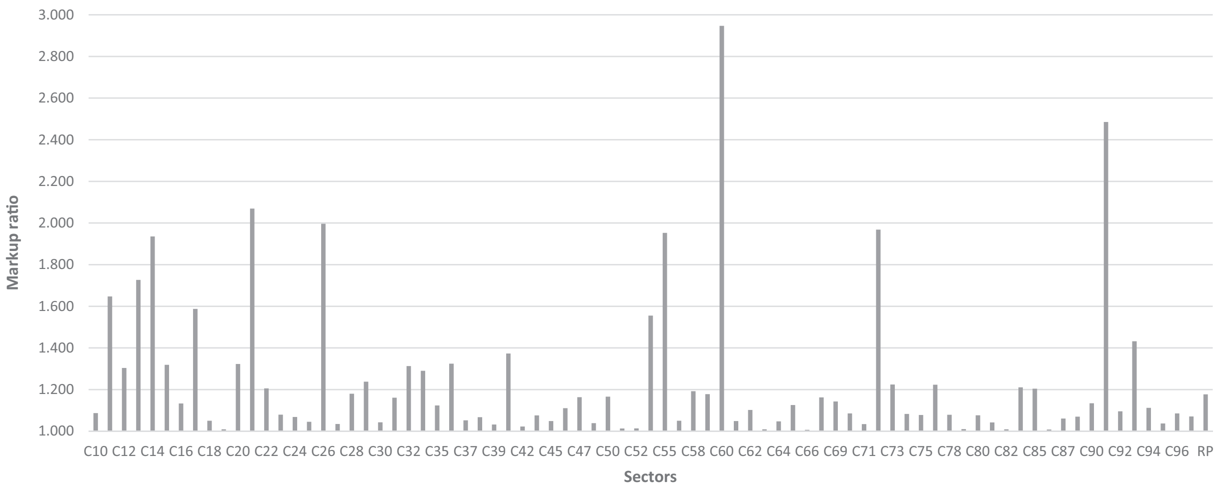

FIGURE 1 Markup ratios across the 79 constituent UK sectors

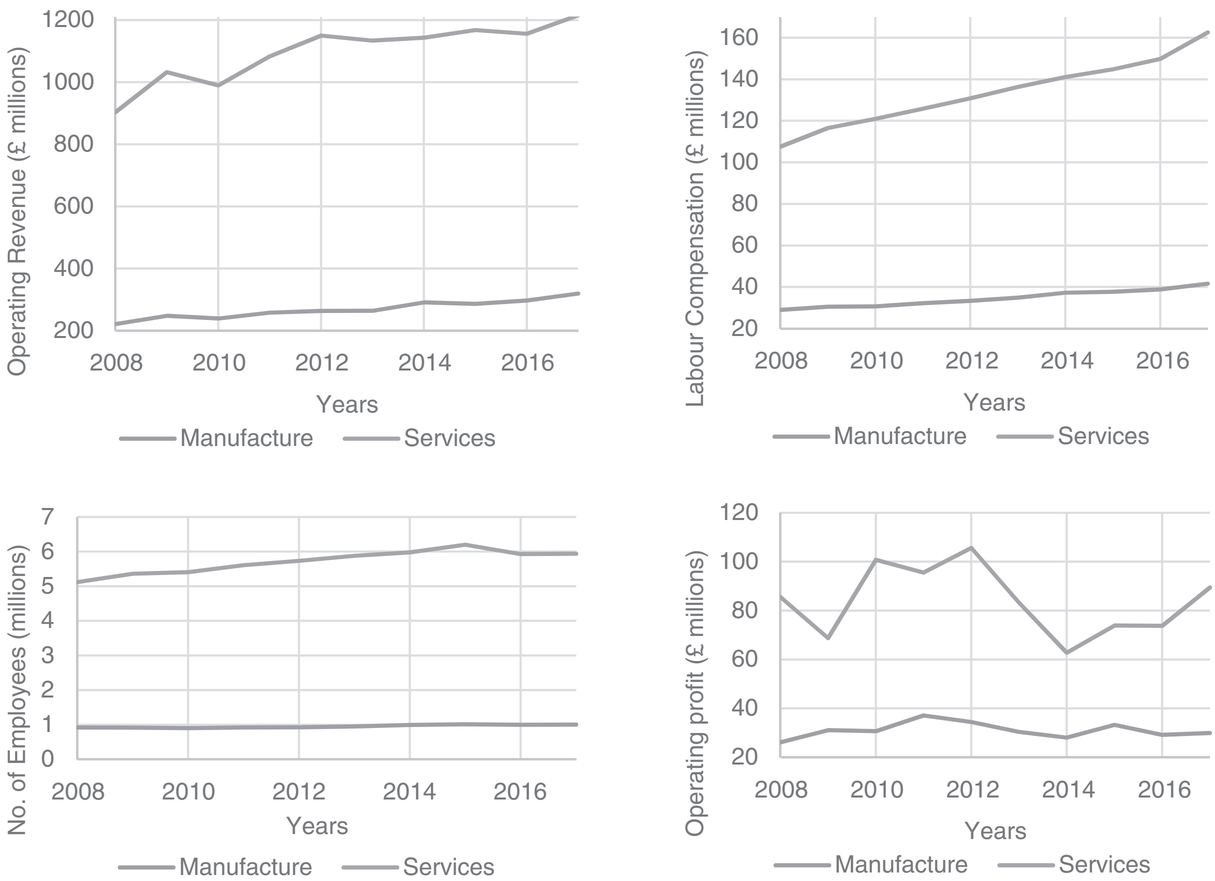

FIGURE 2 Values of operating variables for the UK manufacturing and services industries. *Source*: FAME database

pricing decisions follow the fluctuations of business cycles.

Table 3 provides significant evidence of countercyclical markup ratios across the UK industries. This shows that firms tend to charge lower price–cost margins over normal periods to increase their market share and force their competitors to exit the sector, while they exploit consumer surplus over downturns as they can charge higher markup ratios. The result implies that a 1% increase in the growth rate of real GDP will reduce the level of markups by 0.07%. This outcome is consistent with the studies of Corhay et al. (2017) and Hong (2017,

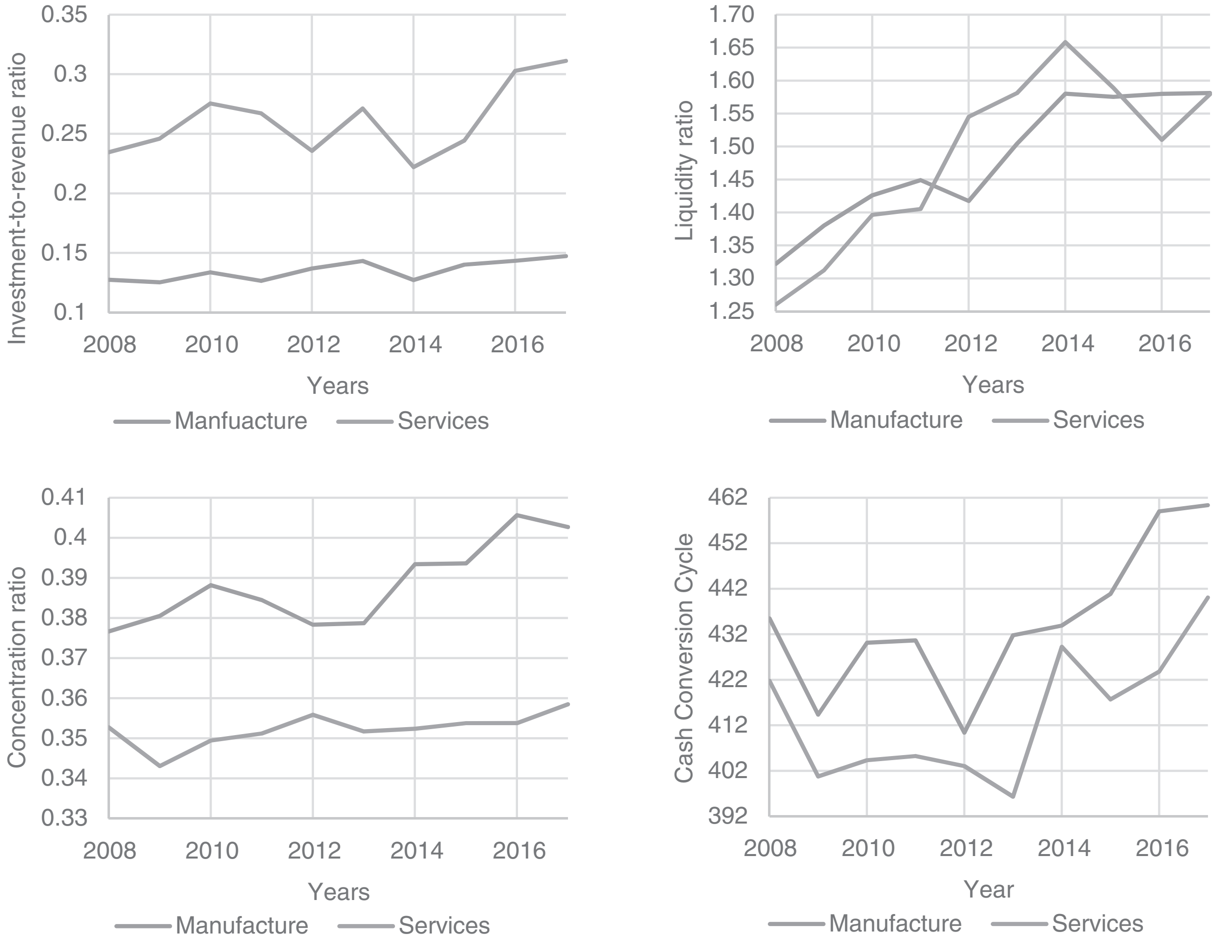

FIGURE 3 Values of market concentration and liquidity-based ratios for the UK manufacturing and services industries. *Source*: FAME database

TABLE 3 Long-run estimate for markup cyclicality

Variables	
μ	1.00
growth of GDP	-0.069^{a} (-2.25)
Wald test	226.14^{b} [0.00]
R^2	0.81

Note: The numbers in parentheses are t statistics. The numbers in brackets are p values.
[a]Rejection of the null hypothesis at the 5% level of significance.
[b]Rejection of the null hypothesis at the 1% level of significance.

2018) contributing to the literature of countercyclical markup behaviour.[22] Therefore, the next step will have to incorporate the estimated values of Tables 1 and 2 in Equations (10a) and (11c) and test the effects of competitive interactions and liquidity constraints on markup cyclicality.

The first step of the estimation process necessitates the investigation of cross section dependence in the variables of the model. The Scaled LM and CD tests developed by Pesaran (2004) are used to test the presence of contemporaneous correlation. Table 4 reports significant results for the constituent variables in the model validating the presence of contemporaneous correlation. This means that a simple pooled OLS estimation will not result in efficient results and thus, additional formulations must be made. The next step includes the identification of first-order integration within the panel series. If at least one of the constituent series is non-stationary, then a panel VAR framework must be formulated to take into account this particular problem. Table 5 shows that none of the panel series are integrated, thus suggesting that a long-run relationship should persist in the model.

As the presence of cointegration is expected among the variables of Equations (10a) up to (11c), Table 6 presents the results of Pedroni (2004) and Westerlund's (2008) cointegration tests. The results validate the initial insight in favour of a significant long-run relationship even when the presence of cross section dependence is considered in the estimation process. This means that the most suitable approach would be a panel

TABLE 4 Pesaran's cross-section dependence tests

	Scaled LM test		CD test	
Variables	**1**	**2**	**1**	**2**
Markup	356.00[a] [0.00]	319.69[a] [0.00]	12.60[a] [0.00]	12.52[a] [0.00]
Growth of GDP	162.00[a] [0.00]	141.94[a] [0.00]	86.11[a] [0.00]	81.11[a] [0.00]
Concentration	201.74[a] [0.00]	199.19[a] [0.00]	33.10[a] [0.00]	26.53[a] [0.00]
Cash convertion cycle	383.73[a] [0.00]	309.28[a] [0.00]	52.03[a] [0.00]	54.12[a] [0.00]
Debt to revenue	318.74[a] [0.00]	320.25[a] [0.00]	10.48[a] [0.00]	11.03[a] [0.00]
Labour to revenue	297.50[a] [0.00]	339.61[a] [0.00]	99.32[a] [0.00]	94.36[a] [0.00]
Liquidity constraints	327.86[a] [0.00]	306.38[a] [0.00]	21.96[a] [0.00]	26.32[a] [0.00]
Investment ratio	322.08[a] [0.00]	330.30[a] [0.00]	32.82[a] [0.00]	25.43[a] [0.00]
Profitability	319.22[a] [0.00]	338.00[a] [0.00]	25.19[a] [0.00]	28.77[a] [0.00]

Note: The results are based on Pesaran's (2004) LM and CD tests. The null hypothesis reflects the absence of cross-sectional dependence in the series. Two models are estimated for each panel series including one and two lags, respectively. The values in brackets are p values.
[a]Rejection of the null hypothesis at the 1% level of significance.

TABLE 5 Pesaran's panel unit root tests

Variables	CIPS	TCIPS
μ	−21.62[a] [0.00]	−24.01[a] [0.00]
$\Delta\mu$	−97.56[a] [0.00]	−100.4[a] [0.00]
cr	−10.56[a] [0.00]	−12.01[a] [0.00]
Δcr	−88.98[a] [0.00]	−90.24[a] [0.00]
ccc	−17.10[a] [0.00]	−19.72[a] [0.00]
Δccc	−105.5[a] [0.00]	−103.8[a] [0.00]
dr	−27.79[a] [0.00]	−30.18[a] [0.00]
Δdr	−115.7[a] [0.00]	−109.3[a] [0.00]
lr	−18.05[a] [0.00]	−21.32[a] [0.00]
Δlr	−99.40[a] [0.00]	−101.7[a] [0.00]
g	−17.90[a] [0.00]	−16.95[a] [0.00]
Δg	−12.47[a] [0.00]	−14.23[a] [0.00]
lc	−24.56[a] [0.00]	−27.84[a] [0.00]
Δlc	−100.5[a] [0.00]	−97.45[a] [0.00]
inv	−23.23[a] [0.00]	−20.18[a] [0.00]
Δinv	−101.8[a] [0.00]	−103.2[a] [0.00]
pr	−15.30[a] [0.00]	−18.44[a] [0.00]
Δpr	−101.9[a] [0.00]	−98.17[a] [0.00]

Note: The values are t statistic values. Δ denotes first differences. Pesaran's (2007) test is conducted including an intercept only. TCIPS corresponds to the truncated CIPS test. Rejection of the null hypothesis suggests stationarity in at least one industry of the panel. The results are reported at lag $k = 2$. The critical values for the test are −2.60 at 1% and −2.41 at 5% level of significance.
[a]Rejection of the null hypothesis at the 1% level of significance.

Vector Error Correction model in order to capture the degree of heterogeneity across firms and deliver unbiased and efficient results.

The presence of cross section dependence is considered by using the CCE estimator developed by Pesaran (2006). Tables 7 and 8 report the long-run estimates capturing the effects of the explanatory variables on the markup ratio and its cyclical behaviour. In particular, the relationship between markup cyclicality and market concentration appears to be negative and highly significant. This means that more concentrated sectors tend to follow predatory pricing strategies in normal periods by charging lower price–cost margins, thus engaging in price wars over market share acquisition (Rotemberg & Saloner, 1986). On the other hand, they are more willing to charge higher markup ratios over downturns especially when consumer demand is relatively inelastic in order to exercise their power and exploit consumer surplus. This rationale is also complemented by the negative relationship between the markup ratio and the concentration index.

This outcome validates the findings of Braun and Raddatz (2016) and Hong (2017) as they argue that more concentrated sectors tend to charge more countercyclical markup ratios because they wish to expand their market share over expansions and exploit it over recessions. According to Rotemberg and Saloner (1986), when market concentration is high, the firm's discount factor for future profits is high and thus, markup ratios appear to exhibit a countercyclical behaviour.[23]

TABLE 6 Panel cointegration tests

	(10a)	(10b)	(10c)	(11a)	(11b)	(11c)
DH_g	11.16[b] [0.00]	10.19[b] [0.00]	10.31[b] [0.00]	13.44[b] [0.00]	11.78[b] [0.00]	10.90[b] [0.00]
DH_p	14.27[b] [0.00]	13.98[b] [0.00]	11.74[b] [0.00]	15.26[b] [0.00]	13.51[b] [0.00]	11.11[b] [0.00]
Panel PP – Statistic	−52.44[b] [0.00]	−90.66[b] [0.00]	−52.05[b] [0.00]	−64.28[b] [0.00]	−68.51[b] [0.00]	−63.79[b] [0.00]
Panel ADF – Statistic	−22.79[b] [0.00]	−48.76[b] [0.00]	−23.79[b] [0.00]	−37.88[b] [0.00]	−45.39[b] [0.00]	−36.71[b] [0.00]
Group PP – Statistic	−182.1[b] [0.00]	−190.5[b] [0.00]	−191.3[b] [0.00]	−164.2[b] [0.00]	−172.3[b] [0.00]	−169.2[b] [0.00]
Group ADF – Statistic	−63.56[b] [0.00]	−68.85[b] [0.00]	−65.57[b] [0.00]	−60.67[b] [0.00]	−63.81[b] [0.00]	−61.98[b] [0.00]

Note: DH_g refers to the group mean Durbin–Hausman statistic and DH_p is the panel statistic as developed by Westerlund (2008). The bandwidth selection M_i corresponds to the largest integer less than $4\left(\frac{T}{100}\right)^{2/9}$ as proposed by Newey and West (1994). The remaining statistics refer to Pedroni's (2004) statistics. They are one-sided tests run with intercept only. The values in brackets are p values.
[a]Rejection of the null hypothesis at the 5% level of significance.
[b]Rejection of the null hypothesis at the 1% level of significance.

TABLE 7 Long-run estimates obtained by the common correlated effects (CCE) technique

Variables	(10a)	(10b)	(10c)
μ	1.00	1.00	1.00
cr	−0.035[a] (−8.84)	−0.002 (−0.53)	−0.032[a] (−5.27)
lc	−0.141[a] (−9.92)	−0.022[a] (−17.13)	−0.006 (−0.56)
inv	0.147[a] (2.87)	−0.002 (−0.46)	0.002[a] (4.95)
pr	0.016[a] (6.67)	0.016[a] (4.37)	0.012[a] (3.17)
ccc	−0.211[a] (19.44)	—	—
dr	—	0.004[a] (6.93)	—
lr	—	—	−0.166[a] (8.80)
Wald test	127.93[a] [0.00]	368.8[a] [0.00]	107.04[a] [0.00]
R^2	0.58	0.43	0.59
Observations	40,400	40,400	40,400

Note: The results of the CCE are obtained by employing the common correlated effects technique proposed by Pesaran (2006). The numbers in parentheses are t-statistics. The numbers in brackets are p values.
[a]Rejection of the null hypothesis at the 1% level of significance.

Subsequently, the proxy variable of liquidity constraints implies that more liquidity constrained sectors tend to charge countercyclical markup ratios. As this proxy is formulated by the interaction of liquidity needs and financial development, it reflects the firm's degree of access to liquid funds. This implies that firms facing more difficulties in acquiring additional liquidity tend to charge a lower price level over normal periods in order to increase their market share and thus, their revenue. However, they cannot adopt such strategy over downturns as liquidity needs and potential revaluated production costs do not provide the opportunity for charging a lower markup ratio. To this end, they are forced to charge a higher price–cost margin in order to exploit consumer surplus from their customers by generating additional revenue serving as a substitute for borrowing.

The countercyclical behaviour of financially constrained firms complements the studies of Bottasso and Sembenelli (2001), Busse (2002) and Bucht, Gottfries, and Lundin (2002). The main argument lies on the inability of such firms to cover their costs of production over downturns by forcing the price level to increase. Moreover, if more liquidity unconstrained firms try to acquire market share through lower markup ratios, the former firms must also invest in the quality of their products to render them appealing to consumers. However, as consumer preferences may change over downturns by focusing on a lower price level than quality, financially constrained firms may be forced to exit the market.[24] Therefore, liquidity acquisition is crucial for entrepreneurial activity and countercyclical markups reflect the attempts of such firms to expand their market share over

TABLE 8 Long-run estimates obtained by the common correlated effects (CCE) technique

Variables	(11a)	(11b)	(11c)
μ	1.00	1.00	1.00
g	-4.757^{b} (−17.08)	-0.462^{a} (−2.13)	-1.783^{b} (−7.98)
$g * cr$	-2.459^{b} (−3.13)	-2.729^{b} (−3.54)	-2.878^{b} (−3.74)
$g * lc$	-0.993^{b} (−18.55)	-0.080^{a} (−2.37)	−0.001 (1.16)
$g * inv$	-0.029^{b} (−2.64)	−0.004 (−1.39)	0.009 (0.92)
$g * pr$	0.164^{b} (14.84)	0.170^{b} (15.63)	0.145^{b} (13.29)
$g * ccc$	-1.355^{b} (−22.79)	—	—
$g * dr$	—	-0.042^{a} (−2.27)	—
$g * lr$	—	—	-0.538^{b} (−14.75)
Wald test	810.67^{b} [0.00]	279.72^{b} [0.00]	509.30^{b} [0.00]
R^2	0.56	0.49	0.50
Observations	40,400	40,400	40,400

Note: The results of the CCE are obtained by employing the common correlated effects technique proposed by Pesaran (2006). The numbers in parentheses are *t*-statistics. The numbers in brackets are *p* values.
[a]Rejection of the null hypothesis at the 5% level of significance.
[b]Rejection of the null hypothesis at the 1% level of significance.

TABLE 9 Long-run estimates obtained by the generalized method of moments (GMM) technique

Variables	(8a)	(8b)	(8c)
μ	1.00	1.00	1.00
cr	-0.005^{a} (−6.77)	-0.002^{a} (−2.73)	−0.235 (1.59)
lc	-0.095^{a} (−16.93)	-0.014^{a} (−3.48)	-0.101^{a} (−3.17)
inv	0.163 (1.49)	0.069 (1.53)	0.001 (0.46)
pr	0.011^{a} (20.10)	0.011^{a} (18.52)	0.008^{a} (16.95)
ccc	-0.151^{a} (−16.32)	—	—
dr	—	-0.004^{a} (−4.77)	—
lr	—	—	-0.158^{a} (−11.80)
$J-$ statistic	12.20 [0.06]	5.30 [0.40]	1.04 [0.83]
R^2	0.61	0.54	0.58
Observations	36,358	36,358	36,358

Note: The GMM estimator is obtained according to Hansen (1982) and Arellano and Bover (1995). The instruments list in the GMM system consists of the lagged values of the endogenous explanatory variables. The numbers in parentheses are *t* statistics. The numbers in brackets are *p* values.
[a]Rejection of the null hypothesis at the 1% level of significance.

normal periods and be prepared for an upcoming recession.

The remaining parameters of the model are the control variables of investment, profitability and liquidity needs. It is expected that investment decisions will follow a procyclical behaviour as firms tend to invest over normal periods in order to be able to absorb any negative shock over downturns.[25] The same rationale may also apply for profitability as firms exercising their market power are more eager to charge a higher markup ratio to increase their profit.

To this end, the procyclical behaviour of profitability is validated by the long-run estimates but the effect of investment appears to be countercyclical. Even if the investment-to-revenue ratio results in higher markup ratios, it seems that more investment-oriented firms tend to charge countercyclical markups. This outcome is not very strong as the coefficient in the latter case is only significant in Equation (11a). Consequently, investment-oriented firms tend to exploit consumer surplus through higher markup ratios but their effect on markup cyclicality may be insignificant. Moreover, more

TABLE 10 Long-run estimates obtained by the generalized method of moments (GMM) technique

Variables	(9a)	(9b)	(9c)
μ	1.00	1.00	1.00
g	-2.855^{b} (−13.85)	-3.015^{b} (−4.96)	-4.607^{b} (−4.98)
$g * cr$	-4.463^{b} (−3.06)	-4.946^{b} (−3.12)	−3.578 (−1.50)
$g * lc$	-3.367^{b} (−13.65)	0.217 (1.79)	0.155 (0.85)
$g * inv$	-0.081^{b} (−3.75)	0.038 (1.73)	0.056^{a} (1.99)
$g * pr$	0.442^{b} (16.49)	0.402^{b} (14.65)	0.419^{b} (15.39)
$g * ccc$	-5.878^{b} (−14.29)	—	—
$g * dr$	—	−0.053 (−1.61)	—
$g * lr$	—	—	-0.743^{b} (−4.81)
$J-$ statistic	6.77 [0.81]	0.47 [0.95]	2.05 [0.53]
R^2	0.60	0.49	0.43
Observations	32,311	32,311	32,311

Note: The GMM estimator is obtained according to Hansen (1982) and Arellano and Bover (1995). The instruments list in the GMM system consists of the lagged values of the endogenous explanatory variables. The numbers in parentheses are *t* statistics. The numbers in brackets are *p* values.
[a]Rejection of the null hypothesis at the 5% level of significance.
[b]Rejection of the null hypothesis at the 1% level of significance.

TABLE 11 Heterogeneous panel non-causality results

Dependent variables	Sources of short-run causation (independent variables)							
	$\Delta\mu$	Δcr	Δlc	Δinv	Δpr	Δccc	Δdr	Δlr
$\Delta\mu$	—	3.69^{b} [0.00]	3.98^{b} [0.00]	5.67^{b} [0.00]	1.31 [0.18]	3.96^{b} [0.00]	1.11 [0.26]	1.08 [0.28]
Δcr	3.27^{b} [0.00]	—	9.40^{b} [0.00]	6.89^{b} [0.00]	−0.17 [0.85]	3.44^{b} [0.00]	0.84 [0.39]	0.83 [0.40]
Δlc	2.96^{b} [0.00]	2.24^{a} [0.02]	—	1.51 [0.12]	2.89^{b} [0.00]	1.46 [0.14]	4.98^{b} [0.00]	0.70 [0.48]
Δinv	6.12^{b} [0.00]	1.46 [0.14]	2.01 [0.04]	—	4.25^{b} [0.00]	1.43 [0.15]	2.22^{a} [0.02]	1.78 [0.07]
Δpr	2.25^{a} [0.04]	3.06^{b} [0.00]	2.77^{b} [0.00]	2.32^{a} [0.02]	—	2.60^{b} [0.00]	1.49 [0.13]	0.06 [0.94]
Δccc	0.71 [0.47]	2.54^{a} [0.01]	4.98^{b} [0.00]	6.08 [0.00]	1.59 [0.11]	—	—	—
Δdr	2.34^{a} [0.01]	1.99^{a} [0.04]	3.48^{b} [0.00]	3.73^{b} [0.00]	1.30 [0.19]	—	—	—
Δlr	1.40 [0.15]	11.05^{b} [0.00]	2.99^{b} [0.00]	2.33^{a} [0.01]	1.77 [0.07]	—	—	—

Note: The values are the Z bar-statistics as reported by Dumitrescu and Hurlin (2012). The numbers in brackets denote *p* values.
[a]Rejection of the null hypothesis at the 5% level of significance.
[b]Rejection of the null hypothesis at the 1% level of significance.

profitable firms may engage in price wars over recessions as their available liquidity will provide them a competitive advantage to force their competitors to exit the sector and increase their market share.

Moreover, the aforementioned rationale is complemented by the countercyclical behaviour of the liquidity needs proxies. The cash conversion cycle, the debt to revenue and labour compensation to revenue ratios exhibit a negative effect on markup cyclicality. This shows that firms facing higher liquidity needs tend to boost their revenue through lower price–cost margins over normal periods in order to increase their market share. To this end, liquidity constrained firms in need for more liquid funds exhibit a countercyclical behaviour in the market as they struggle to substitute inadequate liquidity with additional revenue.

In conjunction with the estimated markup ratios of the manufacturing and services industries, it can be concluded that the constituent UK firms exploit their market power whenever there is an opportunity. More concentrated sectors tend to engage in price wars over normal periods to increase their market share, while liquidity constrained firms try to overcome their lack of sufficient funding by attracting more customers through lower price–cost margins. Consequently, the presence of rigidities in various market factors tend to have different effects on the markup ratio. This may occur as such rigidities reduce the cyclical behaviour of real prices or because capacity constraints force firms to coordinate around static optimal collusive price levels (Braun & Raddatz, 2016).

This outcome is also validated by employing the GMM estimation technique in the underlying model. As the CCE estimator takes into account the presence of cross section dependence, the GMM considers the presence of endogeneity across the sample. The results are presented in Tables 9 and 10 and they bolster the robustness of the long-run estimates. The differences in the estimated values are small, the signs are the same, but some of the explanatory variables become insignificant when the substitute proxies of liquidity needs are included. Overall, the empirical insights validate the argument that countercyclical markup ratios are set by more concentrated industries and liquidity constrained firms.

The final step of the empirical process uses the Dumitrescu and Hurlin (2012) non-Granger causality test in order to investigate the short-run effects amongst the constituent parameters of the model. As presented in Table 11, the markup ratio is caused by every explanatory variable excluding the labour and debt to revenue ratios. This shows that even short-run rigidities and market conditions can influence the pricing decisions of the industries and their competitive interactions in the market. Pricing decisions also cause the main parameters of the model, thus reflecting a contemporaneous feedback between those variables. This means that market structure, liquidity constraints, profitability and investment decisions are also caused by the market price level as it is a crucial determinant of market rigidities. Moreover, bilateral causality between the market concentration and liquidity constraints proxies validate the initial purpose of the model that less liquidity constrained firms tend to enjoy a competitive advantage over their competitors by limiting competition and ultimately, increasing their market share. Finally, the short-run explanatory power of the liquidity needs proxies is not very strong as only the cash conversion cycle variable causes markup cyclicality, while the remaining two have an insignificant effect.

Consequently, the UK manufacturing and services sectors tend to exercise their market power through price wars to expand their market share, while liquidity constraints force firms to charge countercyclical markup ratios to acquire additional revenue as a funding substitute.

5 | CONCLUDING REMARKS

The present study investigates the degree of market power in the UK manufacturing and services sectors by employing the markup formulation developed by De Loecker and Warzynski (2012). The estimation of a panel Vector Error Correction model provides evidence of the price–cost margin charged by the 79 2-digit NACE Rev.2 sectors over 2008–2017. Overall, most of the sectors appear to exhibit a markup ratio close to perfect competition as the joint value of the aggregated industries is 1.19 suggesting that the selling price exceeds the cost of production by 19%. Moreover, the manufacturing industry charges a higher price–cost margin than the services industry; however, the highest markup ratios are charged by services sectors. To this end, the markup values complement the studies of Görg and Warzynski (2003, 2006) concluding that the UK sectors tend to be quite competitive compared to other economies.

The findings of this study also provide significant evidence that more concentrated sectors tend to charge countercyclical markups, thus reflecting their intention to engage in price wars and force their competitors to exit the market (Haltiwanger & Harrington, 1991). This means that markup ratios are lower over normal periods in order to increase market share, but they are significantly higher during recessions as firms wish to exploit consumer surplus. Sectors with more liquidity constrained firms also charge countercyclical markup ratios as they intend to increase their revenue through additional market share in normal periods (Bottasso & Sembenelli, 2001). This rationale is also validated by the liquidity needs proxies as rigidities in acquiring additional funding cause firms to seek additional revenue. Moreover, profitable firms enhance the procyclical behaviour of markups validating the arguments that firms tend to exercise their market power through higher price–cost margins. However, investment-oriented firms may choose not to mitigate investment costs to the markup ratio over normal periods, thus adopting a countercyclical behaviour.

The findings of this study have an empirical importance for the UK economy. More competitive and liquidity constrained sectors experience more countercyclical markup ratios which may be viewed as the result of structural and institutional factors unique to the UK economy.[26] These factors shape the pricing decisions of firms and determine the cyclical behaviour of the markup ratio in the long run. Therefore, UK firms tend to exercise their market power when they get the opportunity to do so, either through higher price–cost margins over downturns or by forcing their competitors to exit the market over normal periods. To this end, firms with lower liquidity constraints enjoy a competitive advantage which is utilized either through additional investment decisions or through profitability boosting.

To conclude, the analysis adds value to the literature of markup cyclicality and the effects of competitive conditions and liquidity constraints on pricing decisions. As the current dataset consists of UK firm-level data, future studies could apply the underlying model on different markets across the globe. Under this perspective, the robustness of the empirical estimates will be enhanced and the cyclical behaviour of markup ratios will be investigated.

DATA AVAILABILITY STATEMENT

The research data used in this study cannot be publicly shared as they were obtained from a licensed portal and any data sharing would compromise legal requirements. The data supporting the empirical findings of this study can be found on the Bureau van Dijk FAME database and information is provided in the data section to know how to source the same dataset. Restrictions apply to the availability of that data which were obtained under license.

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ENDNOTES

[1] Bottasso and Sembenelli (2001) and Busse (2002) found that price wars are more likely to start in normal periods by more liquidity constrained firms as they expect that additional market share will result in higher revenue. Chevalier and Scharfstein (1995, 1996) and Campello (2003) showed that firms facing higher liquidity constraints tend to charge countercyclical markups as they tend to exploit consumer surplus in normal times.

[2] De Loecker and Warzynski (2012) argued that the Hall–Roeger approach results in underestimated values as it does not take into account the effects of unobservable productivity shocks. For this reason, a production function with serially correlated unobserved productivity shocks must be included in the estimation process without any assumptions about constant returns to scale.

[3] In particular, Green and Porter (1984) argued that this is a deviation from a collusive agreement formed when the market is facing a downturn. Under demand uncertainty, optimal incentive equilibrium may involve an episodic recourse to a short-term unprofitable solution, such as a price war.

[4] However, countercyclical markup behaviour is mainly observed across concentrated sectors under implicit collusion especially when firms' discount factor for future profits is high in periods of high demand (Rotemberg & Saloner, 1986).

[5] Bottasso and Sembenelli (2001), Konings, Van Cayseele, and Warzynski (2005), Görg and Warzynski (2006) and Feenstra and Weinstein (2010) also provide evidence that markups tend to fall when firms operate in highly competitive sectors.

[6] Nevertheless, markup behaviour may be uncertain in this case. Usually, higher investment spending is reflected in the final selling price as consumers will have to pay the cost of qualitative improvement. If, however, competition is very intense in the market, firms may be willing to keep the price–cost margin low for some time and absorb the cost of investment through additional funding (Bourlès, Cette, Lopez, Mairesse, & Nicoletti, 2013).

[7] De Loecker and Warzynski (2012) treat V as a bundle of variable inputs and not as individual inputs, thus it is a scalar vector.

[8] It is assumed that input markets are perfectly competitive and thus, $P^V$and r are equal to marginal revenue (De Loecker, Eeckhout and Unger, 2020). Under any structure of imperfect competition, either the marginal cost of production would be higher compared to perfect competition or input prices would be lower as a result of market power (De Loecker, Goldberg, Khandelwal, & Pavcnik, 2016).

[9] There is no need to assume constant returns to scale, as it is assumed by Hall (1988) and Roeger (1995). Given that the Hall–Roeger formulation is estimated in first differences, it provides limitations to the demand function and thus, it results in consistently underestimated markup values (De Loecker & Warzynski, 2012).

[10] The dataset consists of firm-level balance sheets, profit and loss accounts and financial ratios of the constituent UK manufacturing and services firms.

[11] According to the World Bank (2018), the total value added of the services and manufacturing industry to UK GDP in 2017 was 70.2 and 9% respectively, accounting for almost 80% of economic activity.

[12] The research data used in this study cannot be publicly shared as they were obtained from a licensed portal and any data sharing would compromise legal requirements. The data supporting the empirical findings of this study can be found on the Bureau van Dijk FAME database and information is provided in the data section to know how to source the same dataset. Restrictions apply to the availability of that data which were obtained under license.

[13] The value of δ could also be calculated by firm-specific depreciation ratios obtained by the depreciation costs available in the FAME database (see Molnár & Bottini, 2010).

[14] Additional indicators of market concentration could be used, such as the concentration ratio of the four biggest firms in an industry or the limited competition indicator captured by the average of the markup ratios across an industry (Braun & Raddatz, 2016).

[15] Braun and Raddatz (2016) employ a financial underdevelopment proxy based on the credit deposit by the private sector to banks. However, given that this ratio reflects the aggregate economy, it cannot be used in the present study as it does not focus on sectorial activities.

[16] Raddatz (2006) assumed that inventory stock is renewed in each production period, thus the inventory stock at that time captures the equilibrium level of inventory investment.

[17] It is worth mentioning that Pedroni's (2004) tests statistics do not take into account the presence of cross section dependence. This omission assumes that the panel series do not suffer from contemporaneous correlation.

[18] The CCE estimator is preferable compared to the Fully Modified OLS (FMOLS) or the Dynamic OLS (DOLS) estimators as they

result in inefficient estimates under the presence of cross section dependence (Phillips & Sul, 2003).

[19] The Wald statistic converges to normal distribution under the null hypothesis when N and T tend to infinity (Dumitrescu & Hurlin, 2012).

[20] They are the sectors of programming and broadcasting activities (60) and libraries, archives, museums and other cultural activities (91).

[21] However, for some individual sectors this outcome may be different as the Hall–Roeger estimates are higher compared to the ones of De Loecker and Warzynski (2012).

[22] This outcome contradicts the findings of Braun and Raddatz (2016) who argue that markup ratios tend to be procyclical. However, as Bils et al. (2018) highlight, the exclusion of intermediate inputs as a production factor from the markup formulation may result in biased markup estimates.

[23] This outcome however assumes the presence of uncorrelated demand shocks. If a degree of correlation persists, then Haltiwanger & Harrington (1991) argued that incentives for deviating from a collusive agreement will be lower over normal periods as punishment may be severe and coordinated.

[24] Adams, Einav, and Levin (2009) also argued about the importance of liquidity restrictions for consumers. Access to short-term liquidity seems to be a key driver of consumer behaviour and ultimately, of production decisions as higher short-term demand tends to increase the markup ratio in the market.

[25] The importance of innovation in the production process has been highlighted by several studies arguing that price-setting strategies directly reflect changes in investment decisions (Dixit, Pindyck, & Sødal, 1999; Justiniano, Primiceri, & Tambalotti, 2010).

[26] Such factors include corporate governance structures, information technology outsourcing and regulations (Ball, Kothari, & Robin, 2000; Kshetri, 2007; Terjesen, Aguilera, & Lorenz, 2015).

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